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Legume Green Fallow Effect on Soil Water Content at Wheat Planting and Wheat Yield

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ABSTRACT

Growing a legume cover crop in place of fallow in a winter wheat (*Triticum aestivum* L.)–fallow system can provide protection against erosion while adding N to the soil. However, water use by legumes may reduce subsequent wheat yield. This study was conducted to quantify the effect of varying legume termination dates on available soil water content at wheat planting and subsequent wheat yield in the central Great Plains. Four legumes [Austrian winter pea, *Pisum sativum* L. subsp. *sativum* var. *arvense* (L.) Poir.; spring field pea, *P. sativum* L.; black lentil, *Lens culinaris* Medikus; hairy vetch, *Vicia villosa* Roth.) were grown at Akron, CO, as spring crops from 1994 to 1999. Legumes were planted in early April and terminated at 2-wk intervals (four termination dates), generally starting in early June. Wheat was planted in September in the terminated legume plots, and yields were compared with wheat yields from conventional till wheat–fallow. Generally there were no significant differences in available soil water at wheat planting due to legume type. Soil water at wheat planting was reduced by 55 mm when legumes were terminated early and by 104 mm when legumes were terminated late, compared with soil water in fallowed plots that were conventionally tilled. Average wheat yield was linearly correlated with average available soil water at wheat planting, with the relationship varying from year to year depending on evaporative demand and precipitation in April, May, and June. The cost in water use by legumes and subsequent decrease in wheat yield may be too great to justify use of legumes as fallow cover crops in wheat–fallow systems in semiarid environments.

The limited and highly variable precipitation of the semiarid central Great Plains resulted in the traditional winter wheat–fallow crop production system used to stabilize yields (Haas et al., 1974; Hinze and Smika, 1983). That system, especially with the use of tillage to control weeds during the fallow period, leaves the soil surface vulnerable to soil loss and degradation by wind erosion and has very low precipitation storage efficiency (Tanaka and Aase, 1987; Black and Bauer, 1988; Steiner, 1988; Farahani et al., 1998). The introduction of no-till, chemical fallow has reduced the potential for wind erosion and organic matter loss (Bowman et al., 1999), and increased stored soil water available for crop production (Peterson et al., 1996; Nielsen et al., 2002), but has introduced the potential for development of herbicide-resistant weeds when the same herbicide is continually used in the system (Westra, 2004).

A possible solution is the use of legume cover crops during the fallow period, which could protect the soil from erosion while providing organic matter and fixing N to maintain soil quality (Biederbeck et al., 1998). Such a system has been referred to as *green fallow* (Gardner et al., 1993). These systems have sometimes been successful in the cooler regions of the northern Great Plains (Zentner et al., 2001). Zentner et al. (2004) reported that early legume planting and termination dates as well as effective snow catch before spring wheat planting were essential for success with a legume green fallow system in southwestern Saskatchewan. In Montana, lentils grown to full bloom did not reduce subsequent spring profile water compared with tilled or chemical fallow. However, wheat yields in the lentil–spring wheat system were lower than in the wheat–fallow system during the first three cycles of the system due to lower available N following lentil (Cochran and Kolberg, 2002). In some other studies wheat yields following the green fallow period have been decreased due to lower soil water content at wheat planting (Zentner et al., 1996; Schlegel and Havlin, 1997) or due to N deficiency (Pikul et al., 1997). Under the higher temperature, higher evaporative demand environmental conditions of the central Great Plains, the positive economic trade-off between water used by the legumes and their favorable rotation and N fixing effects have not been observed (Vigil and Nielsen, 1998). The objectives of this study were (i) to determine the effect of legume termination date (using four legume species) on available soil water content at winter wheat planting and subsequent wheat yield in a central Great Plains environment, and (ii) to verify the conclusions of Vigil and Nielsen (1998) using a longer study period (6 vs. 2 yr).

MATERIALS AND METHODS

This study was conducted at the USDA Central Great Plains Research Station, 6.4 km east of Akron, CO (40°09′ N lat, 103° 09′ W long, 1384 m). The soil type was a Weld silt loam (fine, smectitic, mesic Aridic Argiustols). The experiment was established in 1994 on a site that had been in a dryland winter wheat–corn (*Zea mays* L.)–summer fallow rotation the previous 3 yr. Before planting the first legume crop, the corn stalks from the 1993 crop were mowed with a flail mower, raked, and removed as bales.

The experiment was arranged in a randomized split-block design with each block replicated four times. Two adjacent areas were alternated each year between legume green fallow/conventional fallow plots and the following winter wheat plots (i.e., both the fallow phase and the wheat phase of the experiment appeared each year). A replication consisted of four main plots, 9.1 m wide and 19.5 m long. The four main-plot treatments consisted of three legume species and a traditional summer fallow treatment. Four legume species were investigated in this study, but only three were tested in any given year (Table 1). In preliminary work (Vigil and Nielsen, 1998), lentil was found to produce less biomass for the same amount of water use as the other legumes, and was therefore replaced

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Abbreviations: AWP, Austrian winter pea; FP, field pea; HV, hairy vetch; IHL, Indianhead lentil.

Table 1. Legume varieties, seeding rates, planting, and termination dates, and winter wheat planting and harvest dates, Akron, CO.

Year	Legume	Variety	Seeding rate, kg ha^{-1}	Legume planting	Legume termination period				Wheat planting	Wheat harvest
					T1	T2	T3	T4		
1994	Austrian winter pea	unknown	95	1 Apr.	31 May	14 June	28 June	19 July	26 Sept.	27 July 1995
	Field pea	'Trapper'	95							
	Lentil	'Indianhead'	35							
1995	Austrian winter pea	unknown	95	6 Apr.	28 June	12 July	26 July	4 Aug.	27 Sept.	12 July 1996
	Field pea	'Trapper'	95							
	Lentil	'Indianhead'	35							
1996	Austrian winter pea	unknown	101	4 Apr	6 June	20 June	2 July	17 July	30 Sept.	10 July 1997
	Field pea	'Trapper'	101							
	Lentil	'Indianhead'	45							
1997†	Austrian winter pea	unknown	134	31 Mar.	23 June	23 June	23 June	23 June	17 Sept.	13 July 1998
	Field pea	'Profi'	134							
	Hairy vetch	unknown	134							
1998	Austrian winter pea	unknown	134	6 Apr.	9 June	17 June	24 June	1 July	25 Sept.	13 July 1999
	Field pea	'Profi'	134							
	Hairy vetch	unknown	134							
1999	Austrian winter pea	unknown	160	31 Mar.	4 June	17 June	2 July	13 July	22 Sept.	30 June 2000
	Field pea	'Profi'	151							
	Hairy vetch	unknown	103							

† All legumes terminated on 23 June due to heavy weed pressure.

with hairy vetch during the last 3 yr of the study. Species, varieties, and seeding rates are given in Table 1.

Weeds in the conventionally tilled summer fallow treatment were controlled with sweep tillage. Typically three or four tillage passes were required to control weeds during the summer fallow period. Weeds were controlled before legume planting with a preplant burndown application of glyphosate [(*N*-phosphonomethyl) glycine] at a rate of 1.1 kg a.i. ha^{-1}. Legumes were planted (generally in early April, Table 1) with a no-till drill equipped with double-disk openers spaced 20 cm apart. All legumes were inoculated with the appropriate strains of *Rhizobium leguminosarum* bacteria at planting. Sub-strip-plots consisted of four legume termination dates (Table 1) separated by about 2-wk intervals and accomplished with a sweep plow. The first termination date was performed when estimated legume dry biomass was approximately 1000 kg ha^{-1}. This generally occurred the first week of June, but was delayed in 2 yr due to cool temperature and low moisture conditions. In 1997 all legumes were terminated on 23 June due to heavy weed pressure and poor competitiveness by the legume canopies. In all years, if weed growth occurred in the terminated legume strips, the plots were sprayed with glyphosate.

In late September of each year winter wheat ('TAM 107') was planted at 2.5 million seeds ha^{-1} (about 67 kg ha^{-1}) with the same drill as used for legume planting (20 cm row spacing). The summer fallow plot was fertilized at wheat planting with 67 kg N ha^{-1} as ammonium nitrate broadcast to the soil surface. This N fertilization rate is about 20% higher than the rate of 56 kg N ha^{-1} that was demonstrated in field (Nielsen and Halvorson, 1991) and long-term simulations (Saseendran et al., 2004) to maximize long-term dryland winter wheat yields in northeastern Colorado.

Plant-available N (NO_3–N and NH_4–N) was assessed each September (except in 1997 when a scheduling conflict delayed sampling until March 1998). Four replicate cores (2.5 cm diam. by 60 cm depth) were taken in each plot. The soil was air-dried and extracted for NO_3–N and NH_4–N with 1 *M* KCl following the method of Keeney and Nelson (1982). The extracts were then analyzed using a LACHAT auto-analyzer (LACHAT Instruments, a Hach Company, Chicago, IL).

Soil water content was measured in the center of each plot at legume and winter wheat planting, and at legume termination and wheat harvest using a neutron probe at soil depths of 0.45, 0.75, 1.05, 1.35, and 1.65 m, and by time-domain reflectometry in the 0.00- to 0.30-m surface layer. Neutron probe access tubes (1.83 m in length) were installed with the top of the tube 0.15 m below the soil surface. A 0.30-m removable tube extension was installed on the top of the buried access tube, extending 0.15 m above the soil surface. The tube extensions were removed before planting and tillage operations. Seeds were hand-planted in the disturbed soil following tube extension installation to ensure representative plant stands around the access tubes. All soil removed during tube extension removal or installation (about 6 L) was saved and replaced to ensure that bulk density of the surface soil around the tube remained essentially unchanged. This method maintained the same soil water measurement sites throughout the length of the experiment. Neutron probe measurements were converted to volumetric water content and depth of available soil water in the 0.00- to 1.80-m soil profile using a calibration equation determined at the time of neutron probe access tube installation and assuming the lower limit of available water as 0.090, 0.120, 0.072, 0.061, 0.082, and 0.111 m^3 m^{-3} for the 0.00- to 0.30-, 0.30- to 0.60-, 0.60- to 0.90-, 0.90- to 1.20-, 1.20- to 1.50-, and 1.50- to 1.80-m soil layers, respectively. These lower limits had previously been determined from the lowest observed water content under growing wheat over the period of 1992 through 1996 in an adjacent experiment on the same soil type (Nielsen et al., 2002), as suggested by Ritchie (1981) and Ratliff et al. (1983). These soil water data, combined with daily precipitation records, were used to estimate wheat evapotranspiration (ET) in each plot by the water balance method, assuming runoff and deep percolation to be negligible.

Wheat was harvested each year (Table 1) with a small plot combine, sampling an area 1.5 m wide and 7.6 m long in the middle of each sub-strip-plot. Yields are reported at 125 g kg^{-1} moisture content.

Available soil water at wheat planting and wheat yield were analyzed using an analysis of variance procedure for a randomized complete block design with data averaged over termination date treatments (Analytical Software, 2003) to determine significant legume species treatment effects and with data averaged over legume species treatments to determine significant termination date effects. In addition, the General Linear Models procedure in SAS (SAS Inst., 1988) was used to calculate single degree of freedom linear contrasts for comparing available soil water at wheat planting and wheat yield in the conventional fallow treatment with those quantities as influenced by legume and legume termination date.

Table 2. Green fallow (Apr.–Sept.) and wheat year (Oct.–June) precipitation (mm), Akron, CO.

Wheat year	Apr.–Sept.	Oct.–Feb.	Mar.	Apr.	May	June	Oct.–June	PE-precip.†
	mm							
1994–1995	193	145	22	63	144	122	496	177
1995–1996	446	35	29	10	112	66	252	510
1996–1997	424	37	2	20	55	78	192	544
1997–1998	298	111	4	17	23	10	165	800
1998–1999	214	54	8	50	78	63	253	517
1999–2000	446	54	40	37	19	19	169	839
				Avg.				
1994–2000	337	73	18	33	72	60	255	565
1908–2002	332	65	21	42	75	62	265	

† PE−precip. = pan evaporation − precipitation totaled over April, May, and June of the wheat growing season.

RESULTS AND DISCUSSION

Precipitation was above normal during the green fallow (April–September) periods of 1995, 1996, and 1999, below normal during the green fallow periods of 1994 and 1998, and near normal during the green fallow period of 1997 (Table 2). Precipitation was above normal during the wheat growing season (October–June) of 1994–1995, below normal during the wheat growing seasons of 1996–1997, 1997–1998, and 1999–2000, and near normal during the wheat growing seasons of 1995–1996 and 1998–1999. Nielsen et al. (2004) have shown the high correlation between winter wheat yields in the central Great Plains and total precipitation received in May and June for conditions when soil water at wheat planting was greater than 170 mm in the 0.00- to 1.20-m soil profile of a Weld silt loam. Total precipitation received in May and June was much below average during the 1997–1998 and 1999–2000 wheat years, near normal for the 1996–1997 and 1998–1999 wheat years, and above normal for the 1994–1995 and 1995–1996 wheat years.

The two most limiting factors to production of winter wheat grain yield in the central Great Plains are water and N (Nielsen and Halvorson, 1991). Measurements of NO_3–N and NH_4–N taken just before winter wheat planting (Table 3) indicate that significant differences in both NO_3–N and NH_4–N were observed before wheat planting the first 2 yr of the study (1994 and 1995). Those years were the establishment years for each location phase of the study. After the establishment years no significant differences were observed in available N levels between the fertilized fallow plots and the unfertilized legume plots (except for the NH_4–N measurement in March 1998 for the 1997–1998 wheat crop). In 1996, 1997, 1998, and 1999 available N levels were not yield limiting but were adequate to very high (Davis et al., 2002) in all plots including the legume treatments. Therefore, we feel confident in attributing yield differences noted in the following discussion to differences in available water caused by the presence of legumes.

The differences in green fallow period precipitation are reflected in the relative amounts of available soil water at wheat planting in the fallow plot (Table 4), with the highest amounts recorded in 1996 and 1999, and the lowest amount observed in 1994. Within a given year, there was no significant effect of legume species on available soil water at wheat planting (averaged over the four termination dates), except in 1998 when available soil water following field pea was 34% higher than observed following Austrian winter pea or lentil. We were not able to identify a reason for this higher water content following field pea in this 1 yr. For each of the six years of the study, available soil water at wheat planting was lower following legume grown during the fallow period than soil water in the conventional till fallow treatment. Averaged over the 6 yr of the study and the four legume termination dates, available soil water at wheat planting was 84 mm lower following a pea green fallow treatment (i.e., available soil water at wheat planting following a pea green fallow treatment was only 74% of the amount available in the traditional fallow treatment). Lentil and vetch were not considered in this average assessment since they were not present in all 6 yr of the study.

Available soil water at wheat planting was significantly reduced (Table 5) with delay in legume termination in every year, except 1997 when all legume plots were terminated on 23 June due to heavy weed pressure. For each of the 6 yr of the study available soil water at wheat planting for each of the four legume termination dates was lower than in the conventional till fallow treat-

Table 3. Amount of NO_3–N and NH_4–N in the surface 0.60 m of the soil profile before winter wheat planting in September in a winter wheat–legume fallow rotation.

Treatment	1994		1995		1996		1997†		1998		1999	
	NO_3–N	NH_4–N	NO_3–N	NH_4–N	NO_3–N	NH_4–N	NO_3–N	NH_4–N	NO_3–N	NH_4–N	NO_3–N	NH_4–N
	kg ha^{-1}											
Austrian winter pea	35	7	3	5	51	11	64	9	34	10	76	13
Field pea	31	7	5	4	43	11	45	9	24	11	59	14
Lentil	35	6	2	5	42	10						
Hairy vetch							58	10	32	11	71	14
Fallow	56	19	23	5	60	14	64	19	25	10	59	14
$P > F$	<0.01	<0.01	0.05	0.40	0.16	0.44	0.07	<0.01	0.16	0.62	0.38	0.81

† Due to a scheduling conflict, the data that would normally have been collected in September 1997 before winter wheat planting was not collected until March 1998 at spring greenup of winter wheat.

Table 4. Available soil water (mm) at wheat planting in conventional till fallow plot and following legumes grown as green fallow at Akron, CO. Data are averaged over four legume termination dates.

Year	Fallow	AWP†	FP	IHL	HV	Avg. legume	Fallow − avg. legume difference	Legume/fallow	P_L‡	P_F§
	mm							%		
1994	245	173	188	172		177	68	72.2	0.20	<0.01
1995	293	202	202	205		202	91	68.9	0.96	<0.01
1996	349	239	261	251		250	99	71.6	0.48	<0.01
1997	288	219	207		205	210	78	72.9	0.82	<0.01
1998	283	158	216		165	180	103	63.6	0.01	<0.01
1999	455	379	380		375	378	77	83.1	0.99	<0.01
Avg.	320	228	243	209	248	236¶	84¶	73.8¶	0.24¶	<0.01

† AWP, Austrian winter pea; FP, field pea; IHL, Indianhead lentil; HV, hairy vetch.
‡ P_L = probability that the null hypothesis of no difference in soil water at wheat planting due to legume species is true (as tested by analysis of variance with legume data only in a randomized complete block design).
§ P_F = probability that the null hypothesis of no difference in soil water at wheat planting between fallow and average legume treatment is true (as tested by single degree of freedom contrast).
¶ Averaged for AWP and FP treatments only.

ment. Averaged over the 6 yr of the study and the two pea species, available soil water at wheat planting was 55 mm lower in the plots with the earliest legume termination (T1) than in the plots with the conventional till fallow treatment. The available soil water in the latest legume termination plots (T4) was 49 mm lower than in the earliest legume termination plots.

These differences in soil water content at wheat planting affected subsequent wheat yield (Table 6). Similar to the soil water results, there were no significant differences in wheat yield due to legume species in any given year or averaged over the 6 yr of the study, but the wheat yield following conventional fallow was always greater than the average yield following legume. The yield on the fallow plot ranged between 2453 and 6032 kg ha^{-1}, averaging 3923 kg ha^{-1}, while yield following the average legume treatment ranged between 1889 and 3733 kg ha^{-1} (averaging 2639 kg ha^{-1}, 67% of the yield following conventional till fallow). Lentil and vetch were not considered in this average assessment since they were not present in all 6 yr of the study.

Within the four legume green fallow termination date treatments, wheat yields were significantly lowered by delay in legume termination date in 3 of the 6 yr (Table 7). Even when legumes were terminated early (T1), 4 of the 6 yr of data showed significantly lower wheat yield than in the conventional till fallow treatment. Wheat yields averaged over the 6 yr of the study were

Table 5. Available soil water (mm) at wheat planting in conventional till fallow plot and following legumes grown as green fallow at Akron, CO, terminated at four dates. Data are averaged over legume species.

Year	Fallow	T1†	T2	T3	T4	P_T‡	P_{T1}§	P_{T2}§	P_{T3}§	P_{T4}§
	mm									
1994	245	228	182	156	144	<0.01	0.05	<0.01	<0.01	<0.01
1995	293	246	216	181	166	<0.01	<0.01	<0.01	<0.01	<0.01
1996	349	307	259	210	225	<0.01	0.04	<0.01	<0.01	<0.01
1997¶	288	213	203	213	213	0.74	<0.01	<0.01	<0.01	<0.01
1998	283	199	186	159	174	0.03	<0.01	<0.01	<0.01	<0.01
1999	455	387	405	364	357	0.03	<0.01	0.05	<0.01	<0.01
Avg.	320	265#	245#	214#	216#	<0.01#	<0.01	<0.01	<0.01	<0.01

† T1, T2, T3, and T4 are four legume termination dates as given in Table 1.
‡ P_T = probability that the null hypothesis of no difference in soil water at wheat planting due to legume termination date is true (as tested by analysis of variance with legume termination date as treatments in a randomized complete block design).
§ P_{T1-T4} = probability that the null hypothesis of no difference in soil water at wheat planting between fallow and each legume termination date is true (as tested by single degree of freedom contrasts)
¶ All legumes terminated on 23 June due to heavy weed pressure.
# Averaged for AWP and FP treatments only.

Table 6. Winter wheat yield in conventional till fallow plot and following legumes grown as green fallow at Akron, CO. Data are averaged over four legume termination dates.

Crop year	Fallow	AWP†	FP	IHL	HV	Avg. legume	Fallow–legume	Legume/fallow	P_L‡	P_F§
	kg ha^{-1}							%		
1994–1995	3979	2670	2663	2632		2655	1112	66.7	0.86	<0.01
1995–1996	6032	3721	4082	2632		3733	1988	61.9	0.27	<0.01
1996–1997	4149	2948	3164	2749		2954	937	71.2	0.06	<0.01
1997–1998	2453	1917	2024		1857	1933	426	78.8	0.82	0.03
1998–1999	4470	2327	2269		2293	2297	1505	51.4	0.96	<0.01
1999–2000	2455	2007	1875		1786	1889	286	76.9	0.80	0.04
Avg.	3923	2598	2680	2671	1979	2639¶	1284¶	67.3¶	0.58¶	<0.0¶

† AWP, Austrian winter pea; FP, field pea; IHL, Indianhead lentil; HV, hairy vetch.
‡ P_L = probability that the null hypothesis of no difference in winter wheat yield due to legume species is true (as tested by analysis of variance with legume data only in a randomized complete block design).
§ P_F = probability that the null hypothesis of no difference in winter wheat yield between fallow and average legume treatment is true (as tested by a single degree of freedom contrasts).
¶ Averaged for AWP and FP treatments only.

Table 7. Winter wheat yield in conventional till fallow plot and following legumes grown as green fallow at Akron, CO terminated at four dates. Data are averaged over legume species.

Crop year	Fallow	T1†	T2	T3	T4	P_T‡	P_{T1}§	P_{T2}§	P_{T3}§	P_{T4}§
	kg ha^{-1}									
1994–1995	3979	3277	2691	2482	2169	<0.01	<0.01	<0.01	<0.01	<0.01
1995–1996	6032	4960	4535	3119	2320	<0.01	<0.01	<0.01	<0.01	<0.01
1996–1997	4149	3855	3555	2152	2252	<0.01	0.31	0.04	<0.01	<0.01
1997–1998¶	2453	1787	1911	2044	1989	0.65	0.01	0.04	0.11	0.07
1998–1999	4470	2069	2591	2012	2514	0.09	<0.01	<0.01	<0.01	<0.01
1999–2000	2455	1924	2115	1780	1736	0.38	0.08	0.25	0.03	0.02
Avg.	3923	3016#	2950#	2319#	2271#	<0.01	<0.01#	<0.01#	<0.01#	<0.01#

† T1, T2, T3, and T4 are four legume termination dates as given in Table 1.
‡ P_T = probability that the null hypothesis of no difference in wheat yield due to legume termination date is true.
§ P_{T1-T4} = probability that the null hypothesis of no difference in wheat yield between fallow and each legume termination date is true (as tested by single degree of freedom contrasts).
¶ All legumes terminated on 23 June due to heavy weed pressure.
# Averaged for AWP and FP treatments only.

907 kg ha^{-1} lower following pea (lentil and vetch were not available in all 6 yr to calculate the average) terminated on the first termination date than wheat yields following conventional till fallow. Wheat yields were 1652 kg ha^{-1} lower following pea terminated on the fourth termination date than wheat yields following conventional till fallow. Applying a value of \$0.1179 kg^{-1} (average price received in Colorado, 1992–2001, www.usda.gov/nass; verified 27 Jan. 2005) to these yield depression values gives a gross income loss ranging from about \$107 ha^{-1} to \$195 ha^{-1} due to the early (T1) and late (T4) legume termination dates, respectively.

When the 6-yr average wheat yields (Table 7) are regressed against the average soil water contents at planting (Table 5), a strong linear relationship between the two quantities is defined [kg ha^{-1} = 15.23 × (mm − 941), r^2 = 0.98]. Wheat yield decreased 15.23 kg ha^{-1} for every millimeter less available soil water at wheat planting due to water use by the legumes. Schlegel and Havlin (1997) reported a similar response in wheat yield following legume green fallow due to soil water availability at wheat planting (15.0 kg ha^{-1} mm^{-1}) in west-central Kansas. Applying the average winter wheat price to the average available water/yield response gives a value of \$1.80 ha^{-1} mm^{-1} of water used by the legume during the green fallow period.

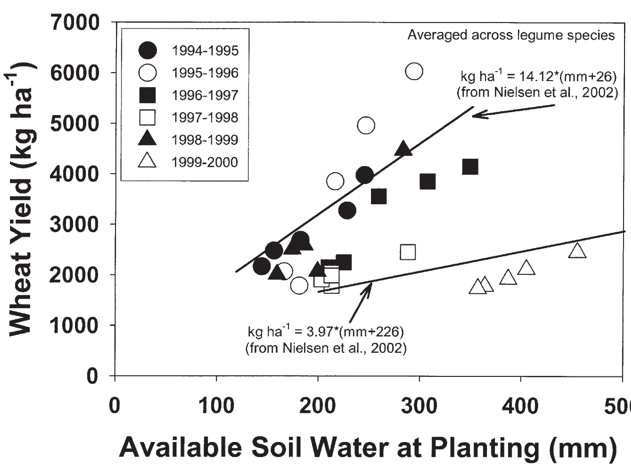

Fig. 1. Response of winter wheat yield to available soil water at wheat planting. Variations in available soil water within a year resulted from legumes growing for different lengths of time.

Nielsen et al. (2002) reported that the winter wheat yield response to available soil water at planting did not follow a single linear relationship, but followed one of two relationships that appeared to be defined by the severity of water stress during the months of April, May, and June. They stated that when the sum of daily pan evaporation minus precipitation over the months of April, May, and June exceeded 650 mm the yield response was defined as kg ha^{-1} = 3.97 × (mm + 226). A much higher yield response to available water for less stressful conditions (April, May, and June pan evaporation minus precipitation less than 650 mm) was defined as kg ha^{-1} = 14.12 × (mm + 26). The data from the current study confirm varying yield response to available soil water at planting (Fig. 1) dependent on water stress condition. The 1997–1998 and 1999–2000 wheat crops were grown under severe water stress conditions, with April, May, and June pan evaporation minus precipitation of 800 and 839 mm, respectively (Table 2). The data from these 2 yr appear to approximately fit the low available water/yield response of Nielsen et al. (2002). Similarly, the data from the other 4 yr of the current study came from years with lower water stress, with April, May, and June pan evaporation minus precipitation ranging from 177 to 544 mm. Data from these 4 yr approximately fit the high available water/yield response of Nielsen et al. (2002).

CONCLUSIONS

Even with early termination dates, legumes grown for green fallow between winter wheat crops used significant amounts of soil water. Wheat yields were linearly related to available soil water at wheat planting, but the yield response varied with the severity of water stress conditions that prevail. Wheat yields were significantly reduced by the use of legume green fallow compared with conventional fallow, regardless of legume type. Legume green fallow could result in significant reductions in gross receipts from winter wheat production and may not be a viable production system for the central Great Plains.

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